

Prevalence of obesity in American Indians and Alaska Natives^{1,2}

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ABSTRACT Obesity is an important risk factor for cardiovascular diseases and non-insulin-dependent diabetes, which are chronic diseases that afflict American Indians and Alaska Natives today. Because American Indians are not represented in most national health and nutrition surveys, there is a paucity of data on actual prevalence of obesity in American Indians. We estimated prevalence of overweight and obesity for American Indian adults, school-age children, and preschool children from existing data. The prevalence of obesity in adults was estimated from self-reported weights and heights obtained from a special survey of American Indians performed as part of the 1987 National Medical Expenditure Survey. Prevalence of obesity in American Indians was 13.7% for men and 16.5% for women, which was higher than the US rates of 9.1% and 8.2%, respectively. Obesity rates in American Indian adolescents and preschool children were higher than the respective rates for US all-races combined. *Am J Clin Nutr* 1991;53:1535S–42S.

KEY WORDS Obesity, North American Indians

Introduction

Malnutrition was once an important problem for American Indians (1). (Throughout this paper, the term American Indians will be used to include both American Indians and Alaska Natives.) At the turn of the century, obesity was rare with the few obese cases found almost exclusively among those living on reservations (2). Medical surveys conducted from 1898 to 1905 on American Indians of the southwestern United States noted rare cases of obesity. It is generally believed that obesity in American Indians has increased since 1940 (3). By the late 1960s high rates of obesity were reported in some tribes (4–7). More recent studies conducted in specific tribes suggest that there are higher rates of obesity for American Indians than for other US populations (8–12).

The magnitude of the obesity problem in American Indians is not well understood or documented. American Indians are not represented in most national health and nutrition surveys, particularly the National Health and Nutrition Examination Surveys (NHANES I and II). Studies to date on obesity prevalence have been based on limited population surveys of specific tribes.

Because obesity is a major risk factor for the chronic diseases, particularly non-insulin-dependent diabetes mellitus (NIDDM), affecting American Indians today (12–22) and because there is

little ongoing collection of data on weight patterns in this group, we estimated the prevalence of overweight and obesity in American Indians by using several different data sources. This paper offers new data on the prevalence of obesity in the general American Indian population by various age groups and a comprehensive review of the literature on obesity in specific American Indian tribes, because an improved understanding of weight patterns among American Indians has important public health implications.

Estimates of prevalence of overweight and obesity for the adult population were based on data collected by the National Medical Expenditure Survey (NMES) of American Indians living on or near reservations. For school-age children the data sources used were the Adolescent Health Survey along with actual examinations of schoolchildren in three American Indian communities. For preschool children information on obesity and overweight was obtained from the Centers for Disease Control (CDC) Pediatric Nutrition Surveillance System (PedNSS). This paper will review data on adults, school-age children, and preschool children and compare American Indians at these ages with comparable groups in the US population.

Methods

Definitions of obesity and overweight

The prevalence of obesity and overweight were assessed by using body mass index (BMI, in kg/m²). For adults the prevalence

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of overweight is defined as the percentage of adults with BMI \geq 85th percentile of the NHANES II reference for men and women aged 20–29 y: BMI \geq 27.8 for men and 27.3 for women (23). The prevalence of obesity is defined as the percentage of adults with BMI \geq 95th percentile: BMI \geq 31.1 for men and \geq 32.3 for women (23). BMI has been reported to be suitable for the evaluation of obesity in children (24) and as a good indicator of total body fat (25, 26). For school-age children the prevalence of overweight is defined as the percentage of children with BMI \geq 85th percentile of the age- and sex-specific NHANES II reference data (23). (The overweight category included the children within the obesity subset.) The prevalence of obesity was defined as the percentage of children with BMI $>$ 95th percentile of the age- and sex-specific NHANES II reference (23). The prevalence of obesity for preschool children was defined as weight-for-height $>$ 95th percentile of the National Center for Health Statistics (NCHS)-CDC reference population (27). The reported rates were analyzed by gender and age and compared with NCHS-CDC reference data.

Data sources

Adults. Data for estimating the prevalence of obesity were obtained from respondents to the first round of interviews of the Survey of American Indians and Alaska Natives (SAIAN) and of the household component of NMES. NMES was conducted by the Agency for Health Care Policy and Research (AHCPR) whereas SAIAN, a component of NMES, was commissioned by the Indian Health Service (IHS) and conducted according to a design similar to NMES. SAIAN was designed to produce unbiased national estimates of health status, health-care use, health-insurance coverage, and expenditures of the population served by IHS, an agency of the US Public Health Service responsible for Indian health care (28). The reference period for both the US and the SAIAN survey components was 1987. The questionnaire and procedures for data collection were similar except for the addition of questions specific to American Indian concerns, such as traditional medicine. Computation and analysis of the prevalence of obesity for those \geq 18 y of age used self-reported weights and heights to define BMI. For the SAIAN survey, trained interviewers collected the data in person whereas for the NMES household component the questionnaire collecting health status data was self-administered. This survey included 3200 American Indian adults.

Although the weights and heights were self-reported, studies conducted in adults revealed that self-reported weights and heights corresponded closely to measured weight and heights, but prevalence estimates were mostly affected at the extremes of the relative weight range (29–33). Thus, this method may underestimate the true prevalence of overweight and obesity in American Indians. Also, inherent in the study design, the prevalence rates of obesity and overweight are for the American Indian population as a whole and do not provide tribal-specific rates; thus, tribal or regional variation cannot be inferred.

School-age children and adolescents. In 1987–1989, American Indian students aged 12–18 y in \sim 200 schools from 50 different tribes participated in an adolescent health survey. Neither schools nor students were sampled systematically. Self-reported weights and heights were obtained from the survey questionnaires. The 12 745 participants included \sim 7% of the youths who were eligible for IHS services and \sim 3% of all American Indian youths aged 12–18 y in the United States. American Indians living in

urban areas or attending public schools were for the most part excluded from this sample.

There are two major limitations to this survey. First, the validity of self-reported weights and heights for adolescents is uncertain, which few reported studies have addressed (34, 35). If systematic underreporting of weight existed among participants in health surveys of individual adolescents, our findings may underestimate the true prevalence of obesity and overweight. Second, the sites where the health surveys of adolescents were conducted were not randomly selected and cannot, therefore, be considered representative of all American Indians.

Measured weights and heights of 746 schoolchildren aged 7–17 y were obtained by IHS diabetes-program health personnel in three specific American Indian communities in Arizona, North Dakota, and Nebraska. All students in grades 4–6 in the North Dakota tribe, 95% of high school students in the Arizona tribe, and 96% of schoolchildren grades 3–12 in two Nebraska tribes were measured in 1989–1990.

Preschool children—ages 0–4 y. The CDC PedNSS provides ongoing surveillance of measured heights and weights of low-income children participating in public health programs. These programs include the special supplemental food programs for women, infants, and children (WIC) and early periodic screening, diagnosis, and treatment programs. In 1988 PedNSS collected data on a total of 2 502 539 preschool children aged 0–4 y in 42 participating states and territories, including 54 774 American Indian children. The prevalence of obesity was calculated for American Indians and US all races by age.

Results

Adults

The 1987 estimated prevalence of overweight in American Indian males \geq 18 y was 33.7% compared with the US rate of 24.1% for males and in American Indian females was 40.3%, which is significantly greater than the US rate of 25.0% (Table 1). American Indian women were more overweight than the men. For both men and women the prevalence varied by age, with the highest prevalence generally occurring between 35 and 64 y.

School-age children and adolescents

Based on self-reported heights and weights of the respondents to the health survey of adolescents, 24.5% of adolescent American Indian males and 25.0% of adolescent American Indian females were overweight. The reported prevalence of obesity was higher for the males (11.1%) than for the females (7.3%). It is apparent that the overall rates of overweight and obesity exceed those of the NHANES II reference data, because they far exceed the expected rates inherent in the definition.

Data from the three American Indian communities in Table 2 show considerable variation in obesity rates by region, although each site indicates excess overweight in these school-age children. Most striking are the adolescents from Arizona, where the prevalence of overweight among females aged 14–17 y was 78.3% and that of obesity was 51.8%.

Preschool children—aged 0–4 y

The prevalence rate of obesity in American Indian children aged 0–4 y participating in public health programs was 11.2%, which is higher than the US all-races rate of 8.1% (Table 3). The highest rate occurred in 1-y-old children (14.5%).



TABLE 1

Prevalence of overweight (BMI \geq 85th percentile) and obesity (BMI \geq 95th percentile) in American Indian and Alaska natives and US all races by gender and age, 1987*

Age	Overweight		Obese	
	American Indians	US all races	American Indians	US all races
Males				
Total (18+ y)	33.7	24.1†	13.8	9.1†
18–24 y	21.5	13.1†	11.0	5.5‡
25–34 y	31.8	19.5†	11.2	7.6
35–44 y	37.8	27.0†	11.2	10.4
45–54 y	49.1	33.8†	28.2	14.1†
55–64 y	45.5	33.1†	16.5	13.0‡
65+ y	25.2	23.0	11.1	5.4‡
Females				
Total (18+ y)	40.3	25.0†	16.6	8.2†
18–24 y	25.2	11.5†	11.7	3.9†
25–34 y	45.1	17.4†	13.8	6.0†
35–44 y	48.5	28.1†	19.7	10.8†
45–54 y	54.0	32.0†	18.7	10.9
55–64 y	45.6	36.2†	18.8	11.5
65+ y	45.6	30.1†	20.7	7.7†

* Agency for Health Care Policy and Research, 1987 National Medical Expenditure Survey (NMES). American Indians and Alaska Natives who are eligible for care through the Indian Health Service (IHS) and who live on or near reservations. BMI, body mass index in kg/m².

† Statistically significant at $\alpha = 0.05$.

‡ Relative SE greater $\geq 30\%$.

Discussion

Adults

Numerous studies of obesity conducted in American Indians in the 1960s through the 1980s showed high rates of overweight and increasing overweight within some tribes (Table 4). These studies used various measures of obesity, including BMI, percent desirable weight, and percent standard weight. The prevalence of obesity was studied by Gray (44) in a Southwest Indian tribe by using IHS data. Obesity was defined as ≥ 95 th percentile of the NCHS norms for age and gender based on both weight and BMI. Males and females of this tribe were significantly heavier than those in the NCHS norms of all ages ≤ 55 y (Fig 1). The prevalence of obesity for females in this tribe was as high as 69% for females aged 19–20 y and 59% for males aged 34–35 y (Fig 2), by using heights and weights recorded in the IHS computer-based Patient Care Information System.

As discussed elsewhere in this symposium, the Pima Indians also are obese and have the highest reported prevalence of NIDDM in the world (12). Obesity for Pima Indians has been increasing in recent years (45). Increases in weight and obesity were noted between 1967 and 1977 and were greatest among young adults < 35 y for whom the average weight gain was between 5.6 and 9.2 kg (45). Studies of Canadian Indians (20, 46), with the exception of the Dogrib Indians of the Northwest Territories (47), also show a high prevalence of obesity. A nutritional survey of semiacculturated Tarahumara Indians in Mexico found that they are predominantly lean, fit persons with rare cases of obesity (48).

Various theories have been offered to explain the high prevalence of obesity in American Indians, namely, increased calorie

TABLE 2

Prevalence of overweight and obesity in three American Indian school-age children populations

	Overweight	Obese
	%	
North Dakota boys, 9–13 y ($n = 56$)*	32.1	3.6
North Dakota girls, 9–13 y ($n = 49$)*	30.6	6.1
Nebraska boys, 7–17 y ($n = 275$)†	32.7	16.4
Nebraska girls, 7–17 y ($n = 224$)†	34.4	13.4
Arizona boys, 14–17 y ($n = 59$)‡	74.6	44.1
Arizona girls, 14–17 y ($n = 83$)‡	78.3	51.8

* 1989 school survey measured height and weight data; Devils Lake Sioux tribe in North Dakota.

† 1990 school survey measured height and weight data; Winnebago and Omaha tribes in Nebraska.

‡ 1990 school survey measured height and weight data; a Southwest tribe in Arizona.

intake and sedentary lifestyle (12). In addition, Neel's thrifty-gene hypothesis in 1962 suggested that obesity, insulin resistance, and NIDDM result from the introduction of a continuous and ample food supply to people who have evolved an ability to store energy efficiently, permitting survival through millennia of feast-famine cycles (49). In a study of Pima Indians, Ravussin et al (50) identified Indian families with a propensity to gain weight. These people, who had low resting metabolic rates, had a fourfold increase in the risk of gaining > 7.5 kg in a 2-y period compared with people with higher metabolic rates.

The role of obesity in relation to the onset of NIDDM has been studied extensively in Pima Indians. Increase in the BMI was significantly associated with increase in the number of new cases (incidence) of NIDDM diagnosed (12). The role of obesity as a risk factor for cardiovascular disease in American Indians is currently under study (51). Whatever the associated health risks, American Indians appear to be more obese than other minority populations.

School-age children and adolescents

Excessive weight and fatness in American Indian school-age children from various tribes were also observed by other inves-

TABLE 3

Age-specific rates of pediatric obesity in American Indians (including Alaska Natives) and US all races, 1988*

Age	American Indians		US all races	
	<i>n</i>	Percentage > 95 th percentile	<i>n</i>	Percentage > 95 th percentile
< 1 y	18 554	11.7	901 829	8.7
1 y	13 211	14.5	585 730	11.3
2–4 y	23 009	9.0	940 624	6.3
Total	54 774	11.2	2 502 539	8.1

* Centers for Disease Control Pediatric Nutrition Surveillance System (CDC Ped NSS), Atlanta, GA, 1988. Obesity defined as weight-for-height > 95 th percentile, National Center for Health Statistics (NCHS)-CDC growth reference population.



TABLE 4

Significant overweight in several American Indian-Alaska Native populations: percent of persons > 120% of desirable body weight

Population	Year	Age	Percentage			Reference
			Total	Male	Female	
Northeast and South						
Oklahoma Seminole	1963	14+ y		23.1	34.3	4
Florida Seminole	1963	14+ y		19.5	39.4	4
Cherokee	1965	35+ y	28.8	24.6	29.8	5
Florida Seminole	1969	2-98 y	43.6			7
Oklahoma Indians	1972-1979	20+ y	77.0	71.0	81.0	36
Penobscot	1981	Adults	35.0			37
Cherokee	1982	18-87 y			59.1	10
Midwest						
Sioux	1970	Adults			60.6	38
West						
Alaska Natives	1958	15-44 y	11.4	4.3	21.1	39
Cocopah	1969	5+ y	65.4	48.8	77.1	6
Pimas	1971	25-44 y			97.0	40
Navajo	1956-1962	30-69 y	15.7	10.9	20.1	41
Navajo	1977	20+ y	37.6	24.1	50.8	42
Pimas	1972	25-34 y		60.0	58.0	12
Navajo	1982	20-90 y			63.0	11
Navajo	1987	20-74 y		42.1	54.7	8
Zunis	1987	20-39 y		33.8	56.2	43
US all races	1976-1980	20-74 y	25.7	24.2	27.1	23

tigators (9, 12, 44, 52-54). In 1979 a survey of 277 Cherokee Indian youths aged 13-17 y in North Carolina found no significant differences in height when compared with a national survey (9). In contrast, mean body weights and triceps skinfold thicknesses of the Cherokee youths were significantly higher than those shown by national reference data. Almost one-half (49.7%) of the Cherokee boys and one-third (31.6%) of the girls had skinfold thicknesses above the 85th percentile. Johnston et al (53) found that American Indian schoolchildren aged 6-17 y living in Minneapolis had markedly greater weight-for-height indices and thicker skinfold thicknesses than the national reference data. Similar high levels of obesity were found in New Mexico: 60 Navajo students in grades 4-6 and 24 Acoma Pueblo children (52). A 1989 survey of all age and sex groups of Navajo youths of both sexes which used measured height and weight data, showed that the mean BMI of Navajo adolescents in all age groups exceeded that of adolescents in the general US population (54).

Other data also support a secular increase in obesity and overweight among American Indian children and adolescents. Pima children 5-18 y of age and of comparable height are now, on average, 6 kg heavier than those at the turn of the century (12). Sugarman et al (54) reported an increase in obesity in Navajo schoolchildren over the past 35 y. Compared with data from 1955, mean heights increased 6.1% for boys and 4.4% for girls in the 1989 survey of 1969 Navajo children aged 5-17 y, whereas mean weights increased 28.8% for boys and 18.7% for girls.

Our findings are consistent with these and other recent studies that suggest that American Indian youths have a higher prevalence of obesity than do adolescents from the general US population. The prevalence of obesity in the three selected American Indian community studies in 1989-1990 was higher than indicated by NHANES II reference data, particularly the extremely high rates of overweight and obesity found in the Arizona Indian

adolescents. The prevalence of overweight and obesity for the American Indian boys and girls from the adolescent health surveys was higher than expected when compared with the NHANES II reference data. It is unclear, however, to what degree possible biases in self-reporting may have influenced the results, but these data are probably underestimates and, therefore, reinforce our supposition that American Indian youths have high rates of obesity.

In contrast to the data presented here on the prevalence of overweight in American Indian children, about one of four school-age children in the United States is overweight (55). Recent longitudinal data from the Bogalusa Health Study indicate that children who are obese over consecutive examinations are likely to become obese adults (56). This carrying of obesity into adulthood is also likely to occur in American Indian children; however, cohort studies are needed to follow these patterns. Because of the concern regarding the consequences later in life of overweight among American Indian youths, particularly in regard to NIDDM, intervention programs to encourage increased physical activity and healthy eating habits are currently being developed. In addition, there is a strong need for systematic surveillance of growth indexes to determine the prevalence and incidence of overweight in American Indians as a whole and within specific tribal groups and to follow these patterns over time.

Preschool children—ages 0-4 y

As in other age groups the prevalence of obesity was high in preschool American Indian children compared with US preschool children. The prevalence of obesity in this population exceeded the 5% of children who would be expected to rise above the 95th percentile, by use of our definition, and exceeded the US all-races rate at each age. Our findings of high rates of obesity



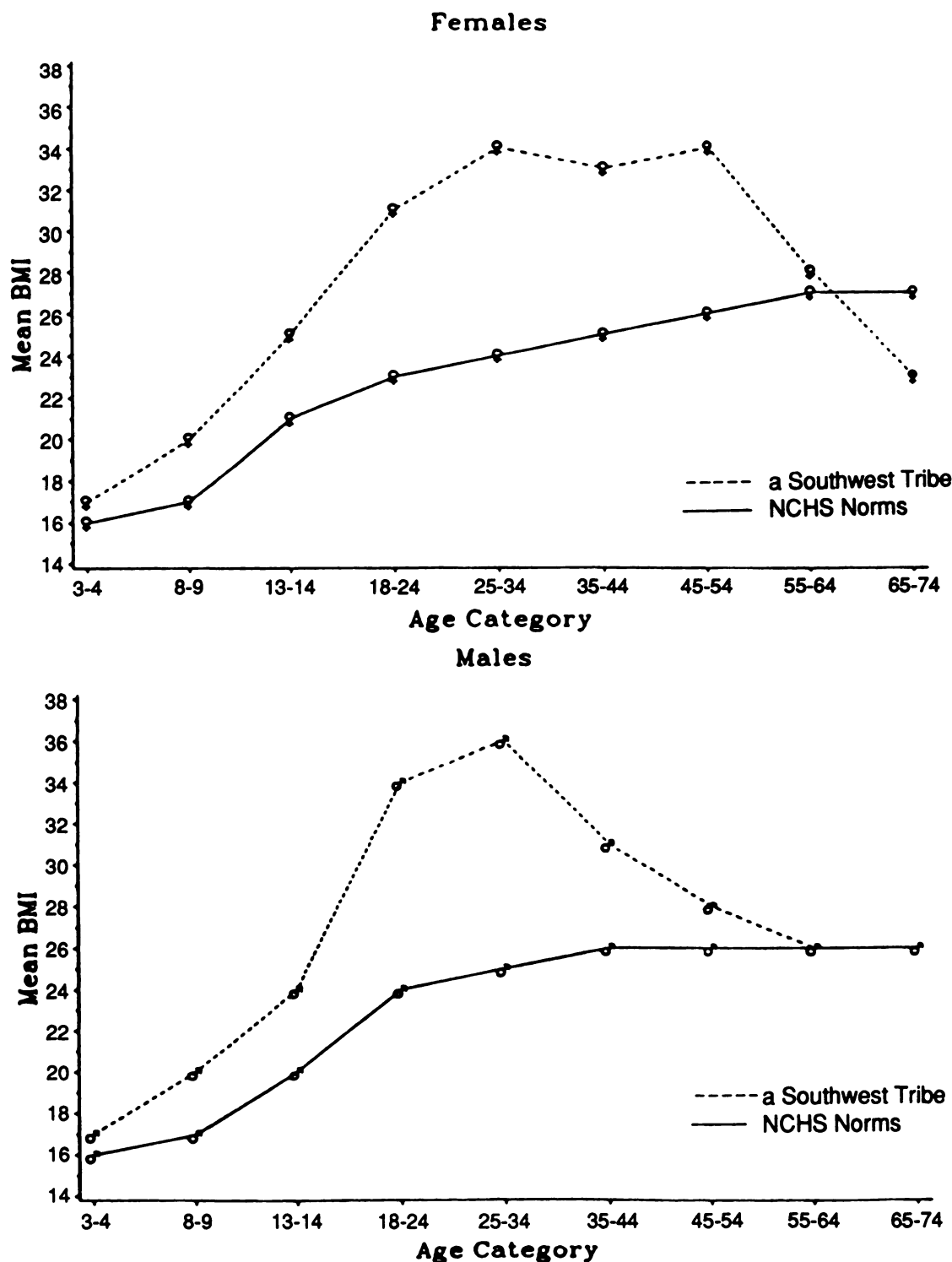


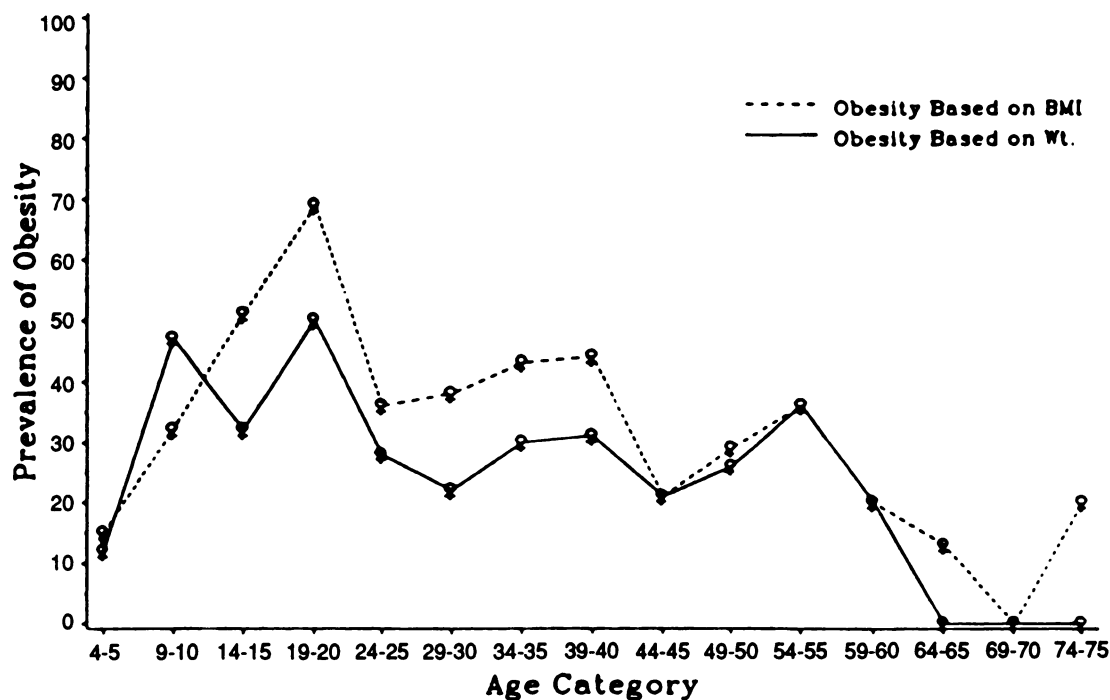
FIG 1. Mean BMI by age category for a Southwest tribe, with National Center for Health Statistics (NCHS) norms. From reference 44.

are consistent with three recent studies of American Indian children. In a 1988 study of Mescalero Apache children aged 1–5 y in New Mexico, Hauck et al found that there was a prevalence of obesity of 17.9% and that children with obese mothers were almost three times more likely to be obese than children with nonobese mothers (FR Hauck, MM Gallaher, MK Serdula, M Yang-Oshida, unpublished observations, 1989). Similarly, children with birth weights ≥ 3 kg were almost three times more

likely to be obese than those with birth weights < 3 kg. In a 1975–1980 study of Navajo children aged ≤ 2 y who attended the Navajo Nation WIC Program, Peck et al (57) found that these children had higher mean percentiles of weight-for-height than did the NCHS-CDC reference population mean. Urban Indian preschool children aged 2–6 y in Minneapolis were found to have higher BMIs than did the comparison NHANES II groups (53).



Females



Males

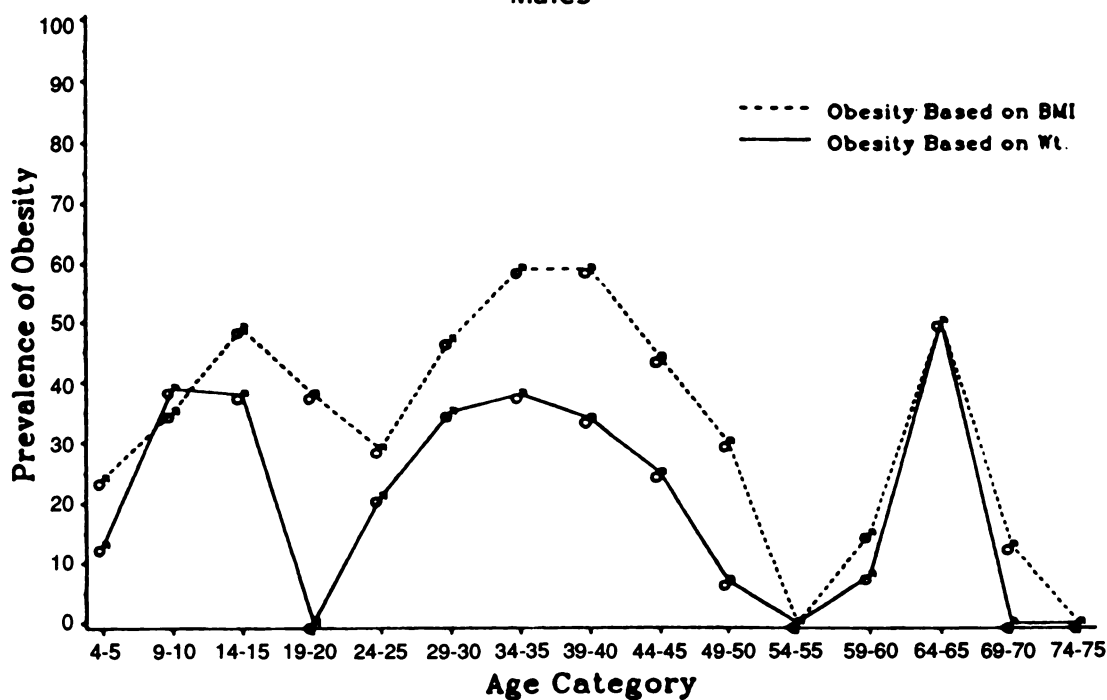


FIG 2. Prevalence of obesity based on weight and BMI by age category in a Southwest tribe, 1986. From reference 44.

Several studies suggest a secular increase in pediatric obesity in American Indians in the past three decades. Anthropometric data obtained in the 1960s from surveys of preschool children in selected tribes, including the Blackfeet, Navajo, White Mountain Apache, and Alaska natives, showed the average American Indian preschool child was below the average US white child in both weight and height (58–60). Clearly that is not true today.


The degree to which obesity in early childhood imposes a risk for obesity in adulthood is of great concern. Several studies sug-

gest that obese children are more likely to become obese adults than are nonobese children (61–63). Johnston (64), in a review of childhood obesity, concluded that the relative risk for obese children becoming obese adults, compared with the risk for nonobese children, may be as high as 2.3. The relative risk of an obese child becoming an obese adult increases markedly with age (65). If compared with lean peers, obese infants are 2.33 times more likely to become obese. By preadolescence the relative risk is > 6. Thus, the older the obese child, the greater the prob-



ability that he or she will become an obese adult. Thus, the apparent increase in rates of obesity in preschool children may presage increasing health problems related to obesity for adults.

Conclusion

Obesity and overweight are more prevalent in American Indians than in the US population in probably all age groups. Adult American Indian men and women were significantly more overweight than the comparable US population. Systematic surveillance data on obesity that are similar to surveillance data on chronic diseases are needed to understand the magnitude of the problem in tribal-specific groups, particularly in the school-age population. Intervention trials are needed urgently in American Indian communities to develop and test effective diet and exercise strategies for weight reduction in overweight individuals. Obesity prevention may have a greater impact than weight-reduction programs. To design and evaluate prevention programs we must know more specifically the ages at which different tribal groups begin to develop weight problems. Thus, longitudinal data on incidence of overweight are needed. 

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References

- Jackson MY. Nutrition in American Indian health: past, present, and future. *J Am Diet Assoc* 1986;86:1561–5.
- Hrdlicka A. Physiological and medical observations among the Indians of Southwestern United States and northern Mexico. Washington, DC: Smithsonian Institute, Bureau of Ethnology, 1908. (Bulletin 34.)
- Sievers ML, Fisher JR. Diseases of North American Indians. In: Rothschild HR, ed. *Biocultural aspects of disease*. New York: Academic Press, 1981:191–252.
- Mayberry RH, Lindeman RD. A survey of chronic disease and diet in Seminole Indians in Oklahoma. *Am J Clin Nutr* 1963;13:127–34.
- Stern JH, West KM, Robey JM, Tirador DF, McDonald GW. The high prevalence of abnormal glucose tolerance in the Cherokee Indians of North Carolina. *Arch Intern Med* 1965;116:842–5.
- Henry RE, Burch TA, Bennett PH, Miller M. Diabetes in the Copah Indians. *Diabetes* 1969;18:33–7.
- Westfall DN, Rosenbloom AL. Diabetes mellitus among the Florida Seminoles. *HSMHA Health Rep* 1971;86:1037–41.
- Sugarman J, Percy C. Prevalence of diabetes in a Navajo Indian community. *Am J Public Health* 1989;79:511–3.
- Story M, Tompkins RA, Bass MA, Wakefield LM. Anthropometric measurements and dietary intakes of Cherokee Indian teenagers in North Carolina. *J Am Diet Assoc* 1986;86:1555–60.
- Terry RD, Bass MA. Obesity among Eastern Cherokee Indian women: prevalence, self-perceptions, and experiences. *Ecol Food Nutr* 1984;14:117–27.
- Wolfe WS, Sanjur D. Contemporary diet and body weight of Navajo women receiving food assistance: an ethnographic and nutritional investigation. *J Am Diet Assoc* 1988;88:822–7.
- Knowler WC, Pettitt DJ, Savage PJ, Bennett PH. Diabetes incidence in Pima Indians: contributions of obesity and parental diabetes. *Am J Epidemiol* 1981;113:144–56.
- Health implications of obesity. National Institutes of Health Consensus Development Conference statement. *Ann Intern Med* 1985;103:1073–7.
- West KM. Epidemiology of diabetes and its vascular lesions. New York: Elsevier North-Holland, Inc, 1978.
- Hubert HB, Feinleib M, McNamara PM, et al. Obesity as an independent risk factor for cardiovascular disease: a 26-year followup of participants of the Framingham Heart Study. *Circulation* 1983;67:968–77.
- Bray GA, Gray DS. Obesity. Part 1—pathogenesis. *West J Med* 1988;148:429–41.
- Barrett-Connor E. Epidemiology, obesity, and noninsulin-dependent diabetes mellitus. *Epidemiol Rev* 1989;11:172–81.
- Jarrett RJ. Epidemiology and public health aspects of noninsulin-dependent diabetes mellitus. *Epidemiol Rev* 1989;11:151–71.
- Manson JE, Colditz GA, Stampfer MJ, et al. A prospective study of obesity and risk of coronary heart disease in women. *N Engl J Med* 1990;322:882–9.
- Young TK, Sevenhuysen G. Obesity in Northern Canadian Indians: patterns, determinants, and consequences. *Am J Clin Nutr* 1989;49:786–93.
- Indian Health Service. IHS chart series book. Rockville, MD: US Public Health Service, 1988.
- Gohdes DM. Diabetes in American Indians: a growing problem. *Diabetes Care* 1986;9:609–13.
- Najjar MF, Rowland M. Anthropometric reference data and prevalence of overweight, United States, 1976–80. *Vital Health Stat* [11] 1987;238. [DHHS publication (PHS) 87-1688.]
- Rolland-Cachera MF, Sempe M, Guillaud-Bataille M, Patois E, Peignot-Guggenbuhl F, Fautrad V. Adiposity indices of children. *Am J Clin Nutr* 1982;36:178–84.
- Himes JH, Bouchard C. Validity of anthropometry in classifying youths as obese. *Int J Obes* 1987;13:183–93.
- Roche AF, Siervogel Roe, Chumlea WC, Webb P. Grading body fatness from limited anthropometric data. *Am J Clin Nutr* 1981;34:2831–3.
- Hamill PV, Johnson CL, Read RB, et al. NCHS growth curves for children, birth–18 years, United States vital and health statistics. *Vital Health Stat* [11] 1977;65. [DHEW publication (PHS) 78-1650.]
- Edwards W, Berlin M. Questionnaires and data collection methods for the household survey and the survey of American Indians and Alaska Natives. Rockville, MD: National Center for Health Services Research and Health Care Technology Assessment, 1989. [DHHS publication (PHS) 89-3450.]
- Rowland M. Reporting bias in height and weight data. *Stat Bull* 1989;April–June:2–11.
- Stunkard AJ, Albaum JM. The accuracy of self-reported weights. *Am J Clin Nutr* 1981;34:1591–9.
- Palta M, Prineas RJ, Berman R, Hannan P. Comparisons of self-reported and measured height and weight. *Am J Epidemiol* 1982;115:223–30.
- Millar WJ. Distribution of body weight and height: comparison of estimates based on self-reported and observed measures. *J Epidemiol Community Health* 1986;40:319–23.
- Stewart AW, Jackson RT, Ford BA, Beaglehole R. Underestimation of relative weight by use of self-reported height and weight. *Am J Epidemiol* 1987;125:122–6.
- Brooks-Gunn J, Warren MP, Rosso J, Gargiolo J. Validity of self-report measure of girls' pubertal status. *Child Dev* 1987;58:829–41.
- Huon GF, Brown LB. Attitude correlates of weight control among secondary school boys and girls. *J Adolesc Health Care* 1986;7:178–82.
- Lee ET, Anderson PS, Bryan J, Bahr C, Coniglione T, Cleves M. Diabetes, parental diabetes, and obesity in Oklahoma Indians. *Diabetes Care* 1985;8:107–13.
- Deprez RD, Miller E, Hart SK. Hypertension prevalence among Penobscot Indians of Indian Island, Maine. *Am J Public Health* 1985;74:653–4.
- Bass MA, Wakefield LM. Nutrient intake and food patterns of Indians on Standing Rock Reservation. *J Am Diet Assoc* 1974;64:36–41.
- Mann GV, Scott EM, Hirsch L, et al. The health and nutritional status of Alaskan Eskimos: a survey of the interdepartmental com-



- mittee on nutrition for national defense, 1958. *Am J Clin Nutr* 1962;11:31-76.
40. Reid JM, Fullmer SD, Pettigrew KD, et al. Nutrient intake of Pima Indian women: relationships to diabetes mellitus and gallbladder disease. *Am J Clin Nutr* 1971;24:1281-9.
 41. Fulmer HS, Roberts RW. Coronary heart disease among the Navajo Indians. *Ann Intern Med* 1963;59:740-64.
 42. DeStefano F, Coulehan JL, Wiant MK. Blood pressure survey on the Navajo Indian Reservation. *Am J Epidemiol* 1979;109:335-45.
 43. Megill DM, Hoy WE. Risk factors for renal disease in a Native American community. *Transplant Proc* 1989;21:3902-5.
 44. Gray N. Obesity in a Southwest Native American tribe: examination of prevalence, predictive factors, and health risks. Tucson: University of Arizona, 1989.
 45. Bennett PH, Knowler WC. Increasing prevalence of diabetes in the Pima (American) Indians over a ten-year period. In: Waldhausl WK, ed. *Proceedings of the 10th Congress of the International Diabetes Federation*. Vienna: Excerpta Medica 1979:507-11.
 46. Montour LT, Macaulay AC, Adelson N. Diabetes mellitus in Mohawks of Kaunawake, PQ: a clinical and epidemiologic description. *Can Med Assoc J* 1989;141:549-52.
 47. Szathmary EJE, Holt N. Hyperglycemia in Dogrib Indians of the Northwest Territories, Canada: association with body fat. *Hum Biol* 1983;55:493-515.
 48. Cerqueira MT, McMurphy Fry M, Connor WE. The food and nutrient intake of the Tarahumara Indians of Mexico. *Am J Clin Nutr* 1979;32:905-15.
 49. Neel JV. Diabetes mellitus: a "thrifty" gene genotype rendered detrimental by "progress"? *Am J Human Genet* 1962;14:353-62.
 50. Ravussin E, Lillioja S, Knowler WC, et al. Reduced rate of energy expenditure as a risk factor for body-weight gain. *N Engl J Med* 1988;318:467-72.
 51. Lee ET, Welty TK, Fabsitz R, et al. The Strong Heart Study: a study of cardiovascular disease in American Indians: design and methods. *Am J Epidemiol* (in press).
 52. Heyward VH, Harris MB. Physical characteristics related to coronary heart disease risk factors: comparison of Hispanics and Navajo, Acoma, and Laguna Indians in New Mexico. *Am J Health Prom* 1988;3:25-32.
 53. Johnston FE, McKigney JJ, Hopwood S, Smelker J. Physical growth and development of urban Native Americans: a study in urbanization and its implications for nutritional status. *Am J Clin Nutr* 1978;31:1017-27.
 54. Sugarman JR, White LL, Gilbert TJ. Evidence for a secular change in obesity, height, and weight among Navajo Indian schoolchildren. *Am J Clin Nutr* 1990;52:960-6.
 55. Gortmaker SL, Dietz WH, Sobol AM, Wehler CA. Increasing pediatric obesity in the United States. *Am J Public Health* 1987;141:535-40.
 56. Freedman DS. Persistence of juvenile-onset obesity over eight years: the Bogalusa Heart Study. *Am J Public Health* 1987;77:588-92.
 57. Peck RE, Marks JS, Dibley MJ, Lee S, Trowbridge FL. Birthweight and subsequent growth among Navajo children. *Public Health Rep* 1987;102:500-7.
 58. Owen GM, Garry PJ, Seymoure RD, Harrison GG, Acosta PB. Nutrition studies with White Mountain Apache pre-school children in 1976 and 1969. *Am J Clin Nutr* 1981;34:266-77.
 59. Carlisle WK, Olson HG, Gorman K, McCracken C, Vanderwagen R, Connor H. Contemporary nutritional status of North American Indian children. In: Moore WM, Silverberg MM, Read MS, eds. *Nutrition, growth, and development of North American Indian children*. Washington, DC: US Government Printing Office, 1969. [DHEW publication (NIH) 72-29.]
 60. Van Duzen J, Carter JP, Secondi J, Federspiel C. Protein and calorie malnutrition among preschool Navajo Indian children. *Am J Clin Nutr* 1969;22:1362-70.
 61. Abraham S, Nordsieck M. Relationship of excess weight in children and adults. *Public Health Rep* 1960;75:263-73.
 62. Zack PM, Harlan WR, Leaverton PE, Coroni-Huntley J. A longitudinal study of fatness in childhood and adolescence. *J Pediatr* 1979;95:126-30.
 63. Stark O, Atkins E, Wolff OH, Douglas JWB. Longitudinal study of obesity in the National Survey of Health and Development. *Br Med J* 1981;283:13-7.
 64. Johnston FE. Health implications of childhood obesity. *Ann Intern Med* 1985;103:1068-72.
 65. Epstein LH, Wing RR, Valoski A. Childhood obesity. *Pediatr Clin North Am* 1985;32:363-79.